

DISTRIBUTION AND CLASSIFICATION OF AQUATIC WEEVILS (COLEOPTERA: CURCULIONIDAE) IN THE GENUS *EUHRYCHIPSIS* IN WASHINGTON STATE¹

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ABSTRACT: During the summers of 1993, 1996 and 1997, we surveyed a total of 66 sites in Washington State to determine the presence and distribution of the aquatic weevil *Euhrychiopsis lecontei*. *E. lecontei* was found in 8 sites in 1993, all in eastern Washington. In 1996 the weevil was found in 9 lakes, 2 of which were located in western Washington. During 1997, we found weevils in 14 sites, all except one were located east of the Cascade Mountains. Previously, the genus *Euhrychiopsis* was considered to have 2 species, *lecontei* and *albertanus*. However, examination of the male genitalia from specimens of both species in this genus from 20 populations across North America showed no differences within or between populations. Therefore, there is only one valid species in the genus *Euhrychiopsis*, namely *lecontei*. *E. albertanus* is a junior synonym [NEW SYNONYMY].

In recent years, the aquatic weevil *Euhrychiopsis lecontei* (Dietz) has been receiving a great deal of attention from both researchers and resource managers as a potential biological control agent of Eurasian watermilfoil (*Myriophyllum spicatum* L.), an aquatic macrophyte native to Europe, Asia and northern Africa (Couch and Nelson 1986). This weevil is native to North America and has been associated with declines of *M. spicatum* in the continent (Creed and Sheldon 1995, Lillie 1996, Jester et al. 1997, Creed 1998). In addition, most of the unexplained declines of *M. spicatum* in North America have occurred within *E. lecontei*'s original range (Creed 1998). Laboratory and field studies conducted in Vermont and Minnesota have concluded that this weevil is a watermilfoil specialist and that it can have a negative impact on Eurasian watermilfoil (e.g. Creed and Sheldon 1995, Sheldon and Creed 1995, Newman et al. 1996, Solarz and Newman 1996).

Given the promising results seen in Vermont and Minnesota and that Eurasian watermilfoil is currently found in 86 lakes and rivers throughout Washington State (Parsons 1997), *E. lecontei* may be an alternative for controlling

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Eurasian watermilfoil in this state. However, several questions about the distribution of *E. lecontei* need to be determined before implementing a biological control program that uses this weevil in Washington State. Prior to our study, it was not known if the weevil occurred throughout Washington or was limited to certain regions. For example, if the weevil is present only in eastern Washington it may not be possible to use it as a biological control agent in the western part of the state. We were also interested in determining which watermilfoil species are serving as host plants for *E. lecontei*. In addition to determining the geographic distribution and host plant usage of *E. lecontei* in Washington, we also resolved the confusion that existed with regards to the taxonomy and classification of weevils in the genus *Euhrychiopsis*. Dietz erected this genus in 1896 as a subgenus of *Phytobius* Schoenherr and based it upon a single species, *lecontei* Dietz. Subsequently in 1932, Brown added a second species, *albertanus* to the genus *Phytobius*. Brown considered *E. lecontei* to be a junior synonym of the European *Eubrychius velatus* Beck, following the consensus of other American weevil specialists. Buchanan (1937) corrected this error and pointed out that *Eubrychius* was restricted to Europe. A previous examination by the second author (CWOB), of specimens identified as *Eubrychius* from numerous museums in the United States, showed that all such North American specimens were misidentified *Euhrychiopsis lecontei*. In Colonnelli's (1986) World Checklist of Phytobiini, *Eubrychius* was considered to be Holarctic. However, Colonnelli did not list any actual localities in the United States or Canada. In addition, he recognized *Euhrychiopsis* as having two species, *lecontei* and *albertanus*. This classification was based on differences in coloration, but it was unclear if these were two separate species or only one. To determine if these color differences are indicative of two species, CWOB examined numerous individuals from across North America within the genus *Euhrychiopsis*, including those collected in the present study.

METHODS

1993 Surveys

The third author (RPC) surveyed 20 lake and riverine sites in Washington for *Euhrychiopsis*. Three of the 20 sites were located west of the Cascade Mountains and 17 were in eastern Washington. Surveys were conducted in late July and early August and specimens were collected by either wading or snorkeling. Eurasian and northern watermilfoil (*M. sibiricum* Komarov = *M. exalbenscens* Fernald) were examined for adult weevils and larval damage. Watermilfoil species were distinguished by morphological differences (Aiken et al. 1979). Larval damage, unique to *E. lecontei*, was identified by examining plant stems for holes and burrowing created by late instar larvae (Creed and Sheldon 1994a, 1995; Sheldon and O'Bryan 1996a; Jester et al. 1997). Sites in addition to those listed in Table 1 were visited, but no attempt was made to collect at these sites

as no watermilfoil was observed from shore.

1996-97 Surveys

Thirty-seven lakes (2 from 1993, Lakes Pateros and Curlew) and a section of the Columbia River by the city of Maryhill were surveyed from mid-July to the end of August, 1996. In 1997, 37 of these sites and an additional 13 (3 from 1993, Okanogan River at Oroville, Whitestone Lake, and the Columbia River at Brewster) were surveyed from early June to early September. Aquatic plant data previously collated by Sharon Walton (1996) and Jenifer Parsons (1997) were used to select survey sites each year. Based on their data, most sites visited were reported previously to have either Eurasian and/or native northern watermilfoil. We tried to avoid sites where Eurasian watermilfoil was being controlled as this can reduce weevil abundance (Sheldon and O'Bryan 1996b). Of the 38 sites we visited in 1996, 16 were located in western Washington, while the remaining 22 were east of the Cascades. In 1997, 24 sites were in western Washington and 26 were east of the Cascades (Table 1).

We surveyed the shoreline of each lake and river site to locate and map watermilfoil beds. Whenever possible, 5 locations within the watermilfoil beds (monotypic and/or mixed species, including plants other than watermilfoils) of each waterbody were selected randomly in 1996. These same locations were surveyed again in 1997. If we did not find any watermilfoil in a location in 1997, we selected a new one randomly. Three snorkel surveys were conducted in each of the 5 locations in both years. Each survey consisted of snorkeling for 5 minutes, examining the top 0.50 m of watermilfoil plants for adult weevils and larval damage; this is the same method used in Vermont (H. Crosson, Vermont Department of Environmental Conservation, Waterbury, VT, pers. comm.). Any adults that were found were collected and larval damage observed was recorded. Representative samples of larval damage were collected in 1996 and 1997. If the survey site consisted of a mixed species bed, plants other than watermilfoils were briefly checked; however our surveys focused primarily on watermilfoil species.

Two plant specimens were collected at each watermilfoil survey site within each waterbody. One plant sample from each site was pressed, while the other specimen was identified. Since most of the collected plants did not have flowers, differentiation of the watermilfoil species was based on stem and leaf morphology (Aiken et al. 1979). If the classification of any specimen was uncertain the plants were identified only to genus.

Weevil Classification

During all 3 survey years, adult weevils were collected when found and the plants they were associated with were noted. Voucher specimens were deposited in CWOB's collection, at the School of Fisheries, University of Washing-

ton, Seattle, WA and in RPC's personal collection. To determine if the genus *Euhrychiopsis* truly consists of 2 species, *lecontei* Dietz and *albertanus* Brown, CWOB compared the coloration and morphology (male genitalia) of the weevils we collected to that of weevils of the same genus from more than 20 populations from Canada (Alberta, Saskatchewan, British Columbia) and the United States (MN, WA, WI, UT, VT, IA, CO, and IL).

RESULTS AND DISCUSSION

Classification

Based on close examination of numerous specimens of *E. lecontei* and *E. albertanus* by CWOB, there is only one valid species in the genus *Euhrychiopsis*, namely *lecontei* Dietz. *E. albertanus* Brown is a junior synonym of the latter [**new synonymy**]. Dissections of male genitalia showed that there are no differences within or between populations. The specimens examined represent a single species with a wide range of color forms which vary so greatly that they should not be treated even as subspecies. In fact, multiple color forms have been collected within the same waterbody in at least Washington and Wisconsin (R. Lillie, Wisconsin Department of Natural Resources, Monona, WI; pers. comm.). Consequently, any specimens which key to *Euhrychiopsis* using Colonnelli's key (1986) can be treated as *E. lecontei* Dietz.

Typically, eastern North American populations of *E. lecontei* are distinctly mottled. Their dorsal surface ranges from pale yellowish brown to greenish brown, mixed with dark brown to black maculae and a yellowish venter. Westward populations tend to become darker in a clinal fashion, with the maculations becoming larger and more predominant. Typical *E. albertanus* were nearly black with a distinct whitish postcutellar sutural vitta and a whitish venter. However, in all the series of *albertanus* from the western prairie (including the type locality) that were examined by CWOB, dark mottled specimens also occurred in addition to black specimens. West of the Rocky Mountains in Washington and British Columbia, dark mottled forms are present, and so far no solid black forms have been collected. Even though there is this great color variation, it is clear that this is a single species. Hence, *Euhrychiopsis* is a monotypic genus. The latter is encouraging because future control efforts involving weevils from this genus need only to focus on one species, *lecontei* Dietz.

Distribution of *E. lecontei*

In 1993, we found *E. lecontei* in 8 of the 20 sites surveyed; all sites were in eastern Washington. During the 1996 surveys, *E. lecontei* was present in 9 of the 38 sites. Two of the lakes, Sawyer and Meridian, were located in western Washington, while the other 7 were in eastern Washington. Only 2 of the 8 weevil sites from 1993, Lake Pateros and Curlew Lake, were surveyed in 1996. Both larval damage and 2 adults were collected in Curlew Lake in 1996. We did not find either in Lake Pateros, however only a section of the eastern shore of

the lake was surveyed. In 1997, we found *E. lecontei* in 14 of the 50 sites surveyed. All sites except for Lake Sawyer were in eastern Washington. Only 3 weevil sites from 1993, Lake Pateros, Curlew Lake and the Okanogan River at Oroville, were surveyed in 1997. We found larval damage both in Curlew Lake and the Okanogan River at Oroville, while in Lake Pateros we did not detect any adults or larval damage. In addition, all of the weevil sites from 1996 had larval damage and/or adults in 1997, except for Lake Meridian where neither were detected.

To date, we have found *E. lecontei* in 21 lake and riverine sites around Washington (Table 1). Most of these sites were located in eastern Washington (19), however we did find *E. lecontei* in western Washington. West of the Cascades, the weevil was present only in King County, in Lakes Meridian and Sawyer. In eastern Washington, *E. lecontei* occurred in 7 counties, Chelan, Ferry, Grant, Lincoln, Okanogan, Pend Oreille and Spokane. Only 3 of the 19 sites with weevils east of the Cascades were located in the Columbia and Okanogan Rivers. We found the greatest number of adult weevils in Fish Lake (17) in 1996, followed by Sawyer Lake (9) in 1997. The presence of *E. lecontei* in eastern and western Washington is promising, as this would facilitate future biological control programs using this weevil in both regions. In addition, it is encouraging that we found *E. lecontei* in the Columbia and Okanogan Rivers as well as in King County, because Eurasian watermilfoil is a nuisance in these areas. In fact, the earliest herbarium specimen of Eurasian watermilfoil in Washington State was collected from Lake Meridian in the mid 1960's (Parsons 1997).

We also found that in Washington, *E. lecontei* is associated with both Eurasian and northern watermilfoil (Table 2), the latter being native to the state and North America. To date, *E. lecontei* has been found primarily on Eurasian watermilfoil in western Washington. In contrast, in eastern Washington weevils were found in more waterbodies with northern watermilfoil than Eurasian watermilfoil. Northern watermilfoil is widely distributed throughout Washington, particularly east of the Cascades. In 11 of the 19 weevil sites in eastern Washington, *E. lecontei* was associated with northern watermilfoil. Of the remaining 8 weevil sites in eastern Washington, weevils were present on Eurasian watermilfoil in 6 (Lake Pateros, Sacheen Lake, Evergreen Lake, Columbia River at Entiat, Okanogan River at Oroville and below Lake Osoyoos), while in the other 2 sites (Aeneas and Stan Coffin Lakes) *E. lecontei* occurred on both Eurasian and northern watermilfoil. Because our surveys focused primarily on watermilfoil species, we can not comment on the host specificity of *E. lecontei*. However, our data do provide further evidence that northern watermilfoil is a native host of *E. lecontei*. In at least 7 lakes with weevils, *M. sibiricum* has been the only watermilfoil species present. Our results corroborate those of Creed and Sheldon (1994b) who found *E. lecontei* in 10 lakes in Alberta, Canada where Eurasian watermilfoil was absent, but northern watermilfoil was present.

Table 1. Distribution of *Euhrychiopsis lecontei* in Washington State.

Lake or river	County	Location ¹	Watermilfoil spp. ²				<i>Euhrychiopsis lecontei</i> ³			
			1993	1996	1997	1997	1993	1996	1997	1997
Lake Chelan at Mill Bay Park Columbia R.	Chelan	T30N,R21E,S19	EWM	—	—	—	None	—	—	—
at Entiat	Chelan	T26N,R21E,S16	EWM	—	—	—	A(5)	—	—	—
Lake Pateros near Wells Dam	Chelan	T29N,R24E,S6	EWM	EWM	EWM	EWM	A(2)	None	None	None
Wapato Lake	Chelan	T28N,R21E,S23	NWM	—	—	—	LD	—	—	—
Beaver Lake	Clallam	T31N,R12W,S9	—	—	—	NWM	—	—	—	None
Lake Sutherland	Clallam	T30N,R8W,S22	—	—	—	NWM	—	—	—	None
Silver Lake	Cowlitz	T10N,R1W,S36	EWM	—	—	—	None	—	—	—
Curlew Lake	Ferry	T38N,R33E,S28	NWM	NWM	NWM	NWM	A(2)	A(2), LD	LD	LD
Columbia R. at Pasco	Franklin	T9N,R30E,S3	EWM	—	—	—	None	—	—	—
Scootney Res Lake	Franklin	T14N,R30E,S27	—	EWM	EWM	EWM	—	None	None	None
Babcock Ridge Lake	Grant	T20N,R23E,S10	—	EWM	EWM	EWM	—	None	None	None
Billy Clapp Lake	Grant	T23N,R28E,S36	—	EWM	—	None	—	None	None	None
Burke Lake	Grant	T19N,R23E,S15	—	NWM	NWM	NWM	—	None	None	None
Canal Lake	Grant	T17N,R29E,S33	—	NWM	NWM	NWM	—	LD	A(1), LD	LD
Corral Lake	Grant	T17N,R28E,S15	—	NWM	NWM	NWM	—	LD	A(5), LD	LD
Evergreen Lake	Grant	T19N,R23E,S22	—	—	—	EWM	—	—	—	—
Stan Coffin Lake	Grant	T19N,R23E,S10	—	NWM	NWM	NWM	—	None	A(4), LD	LD
near Quincy	Grant	T17N,R29E,S10	—	& EWM	& EWM	& EWM	—	—	LD	LD
Warden Lake	Grant	T34N,R1E,S35	—	NWM	NWM	NWM	—	None	—	None
Cranberry Lake in Whidbey Island	Island	—	—	—	—	—	—	—	—	—
Bass Lake	King	T20N,R6E,S2	—	EWM	EWM	EWM	—	None	None	None
Lake Desire	King	T23N,R5E,S36	—	EWM	EWM	EWM	—	None	None	None
Lake Dolloff	King	T21N,R4E,S10	—	EWM	EWM	EWM	—	None	None	None
Margaret Lake	King	T26N,R7E,S3	—	—	—	WESWM	—	—	—	None
Lake Meridian	King	T22N,R5E,S27	—	EWM	EWM	EWM	—	A(3), LD	LD	LD

Lake or river	County	Location ¹	Watermilfoil spp. ²				<i>Euhrychiopsis lecontei</i> ³		
			1993	1996	1997		1993	1996	1997
Neilson (Holm) Lake	King	T21N,R5E,S14	---	EWM	EWM		---	None	None
North Lake	King	T21N,R4E,S15	---	---	WWM		---	---	None
Lake Sawyer	King	T21N,R6E,S4	---	EWM ⁵	EWM ⁵		---	A(5), LD	A(9), LD
Shadow Lake	King	T22N,R6E,S7	---	---	None		---	None	None
Shady Lake	King	T22N,R5E,S1	---	None	EWM		---	None	None
Sar Lake	King	T22N,R4E,S34	---	EWM	EWM		---	None	None
Lake Wilderness	King	T22N,R6E,S22	---	EWM	EWM		---	None	None
Columbia R.	Klickitat	T2N,R15E,S13	---	EWM	EWM		---	None	None
at Maryhill									
Horsethief Lake	Klickitat	T2N,R14E,S19	---	EWM	EWM		---	None	None
Swofford Pond	Lewis	T12N,R3E,S26	EWM	---	---		None	---	---
Fishtrap Lake	Lincoln	T21N,R39E,S12	---	NWM ⁶	NWM ⁶		---	A(2), LD	A(3), LD
Aeneas Lake	Okanogan	T37N,R26E,S25	---	NWM	NWM		---	A(3), LD	A(1), LD
near Tonasket					& EWM				
Columbia R.	Okanogan	T29N,R23E,S35	None	---	---		None	---	---
at Pateros									
Columbia R.	Okanogan	T30N,R24E,S23	EWM	---	EWM		None	---	None
at Brewster									
Conconully Lake	Okanogan	T35N,R25E,S6	---	WS ⁷	EWM		---	None	None
Fish Lake	Okanogan	T36N,R25E,S22	---	NWM	NWM		---	A(17), LD	LD
Little Twin Lake	Okanogan	T34N,R21E,S15	---	None	None		---	None	None
Okanogan R.	Okanogan	T39N,R27E,S21	EWM	---	EWM		A(5)	---	LD
at Oroville									
Okanogan R. 300 m	Okanogan	T39N,R27E,S28	EWM	---	---		LD	---	---
below Lake Osyoos									
Lake Osyoos	Okanogan	T40N,R27E,S22	EWM	---	---		None	---	---
Palmer Lake	Okanogan	T39N,R25E,S13	---	NWM	None		---	None	None
Spectacle Lake	Okanogan	T38N,R26E,S2	NWM	---	---		LD	---	---
Whitestone Lake	Okanogan	T38N,R27E,S17	EWM	---	EWM ⁵		None	---	None
Fan Lake	Pend Oreille	T30N,R43E,S32	---	NWM	NWM		---	None	A(5), LD
Nile Lake	Pend Oreille	T37N,R42E,S35	---	---	EWM		---	---	None

Lake or river	County	Location ¹	Watermilfoil spp. ²				<i>Euhrychiopsis lecontei</i> ³	
			1993	1996	1997	1993	1996	1997
Pend Oreille R. near Newport	Pend Oreille	T55N,R45E,S18	EWM & NWM	---	---	None	---	---
Sacheen Lake	Pend Oreille	T31N,R44E,S30	EWM	---	---	A(6)	---	---
Egg Lake in San Juan Island	San Juan	T36N,R3W,S33	---	---	NWM ⁴	---	---	None
Beaver Lake	Skagit	T34N,R5E,S7	---	NWM	NWM	---	None	None
Clear Lake	Skagit	T36N,R9E,S23	---	EWM	EWM	---	None	None
Lake Erie	Skagit	T34N,R1E,S11	---	---	NWM	---	---	None
Heart Lake	Skagit	T36N,R7E,S5	---	NWM	NWM	---	None	None
Lake McMurray	Skagit	T33N,R5E,S30	---	---	EWM	---	---	None
Sixteen Lake	Skagit	T33N,R4E,S15	---	---	EWM	---	None	None
Loma Lake	Snohomish	T31N,R4E,S35	---	EWM	NWM ⁸	---	None	None
Badger Lake	Spokane	T21N,R41E,S4	---	NWM ⁹	NWM	---	None	A(1), LD
Long Lake (Refuge)	Spokane	T23N,R41E,S26	---	---	None	---	---	None
Williams Lake	Spokane	T21N,R40E,S13	---	NWM ⁶	NWM ⁶	---	A(1), LD	LD
Jumpoff Joe Lake	Sevens	T31N,R40E,S36	NWM	---	---	None	---	---
Waitis Lake	Stevens	T31N,R40E,S17	NWM	---	---	None	---	---
Hicks Lake	Thurston	T18N,R1W,S27	None	---	---	None	---	---
Whatcom Lake	Whatcom	T38N,R3E,S28	---	EWM	EWM	---	None	None

¹The location of the waterbodies is reported as Township (T), Range (R), and Section (S). ²Watermilfoil species found in the waterbody and where larval damage and/or adults were present. EWM=Eurasian watermilfoil; ---=sites that were not surveyed in a particular year; NWM=northern watermilfoil; WESWM=western watermilfoil; and WWM=whorled watermilfoil; WS=watermilfoil species. ³A=adult weevils. The total number of adults collected is shown in parentheses. This number includes adults that were collected during weevils surveys and while mapping the watermilfoil. LD=larval damage. ⁴Whorled watermilfoil might have been present also in Egg Lake. ⁵Eurasian watermilfoil occurred throughout the littoral zone of Lakes Sawyer and Whiteside, but a few plants of northern watermilfoil were also present. ⁶Northern watermilfoil was the predominant watermilfoil species in Fishtrap and Williams Lakes, however a few plants of Eurasian watermilfoil were found. ⁷Unclear if some of the watermilfoil in Conconully Lake was Eurasian watermilfoil or another species. ⁸A few scattered plants of western watermilfoil may have been present in Loma Lake. ⁹Uncertain if some of the watermilfoil plants in Badger Lake were northern or another species.

There are several questions that still need to be answered before implementing a biological control program with *E. lecontei* in Washington State. For example, do differences exist in the life history of *E. lecontei* in eastern and western Washington since both regions have very different climatic conditions? Most, if not all of the lakes in eastern Washington where weevils have been collected freeze during the winter; this is not the case for the lakes with weevils in western Washington. Also, does the weevil interact with other native species of watermilfoil in Washington? We are uncertain if northern watermilfoil is the only native plant that is a host for *E. lecontei* in Washington. In addition, we do not know what impact the weevil may have on other native watermilfoils found in the state, such as western (*M. hippuroides* Nuttall) and whorled (*M. verticillatum* L.) watermilfoils. Finally, how do weevil densities in Washington State compare with those of other states where *E. lecontei* has been associated with declines of Eurasian watermilfoil (e.g., Illinois, Vermont, and Wisconsin [Jester et al. 1997])? The "low" numbers of weevils collected in our study do not necessarily imply low weevil densities. Similarly, the fact that weevils were not found in most of the waterbodies surveyed (60% in 1993, 76% in 1996 and 72 % in 1997) does not necessarily indicate that weevils are not present there. Local areas where weevils were present may not have been surveyed. In addition, lakes may have been surveyed too early or too late in the season, thus missing peak weevil densities.

Table 2. Number (%) of lakes surveyed in Washington State with *Euhrychiopsis lecontei* and the watermilfoil species present.¹

	Eastern Washington	Western Washington
No. of waterbodies surveyed	39	27
No. of waterbodies with <i>E. lecontei</i>	19 (48.7%)	2 (7.4%)
No. of waterbodies with Eurasian watermilfoil	6 (31.6%)	2 (100%)
No. of waterbodies with northern watermilfoil	11 (57.9%)	0
No. of waterbodies with Eurasian & northern	2 (10.5%)	0

¹ Data from 1993, 1996 and 1997 are presented.

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